The Allegory of the Humidifier:
A case study of Return on Investment in Systems Engineering

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Abstract. Following is a case study of the down stream affects of short term decisions based solely upon short-horizon cost savings. A case is made for "no decision is a island" and documents how a simple (<$10k) initial decision had million dollar impacts down stream. This allegory also points out the importance of getting our Systems Engineering right before launching into other productivity improvement programs--JIT, reengineering efforts, cycle time reduction, Continuous Improvement, and others--all of which points out the key importance that Systems Engineering should be playing in our companies.

INTRODUCTION

We have always had the feeling that Systems Engineering was a good thing to do, that defining requirements before design and optimizing the whole system was a good way of doing business. Convincing management of the importance of Systems Engineering, making time available in the project schedule for systems analysis, generating specifications defining customer needs, and other arguments always made sense to Systems Engineers from a risk reduction and cost avoidance perspective. But as schedule crunches, today's fire drill, and project cost reductions took hold, Systems Engineering took a back seat to "getting the hardware out the door". Although Systems Engineering always made sense logically, we could never pin it down financially. Although we can trace back many high cost project failures to mistakes made during the requirements definition stage of a project, we have never been able to convince the accountants and managers of the value of investing in cost avoidance, risk reduction, customer understanding rather than hard-to-pin-down Return on Investment (ROI) numbers. Put another way Systems Engineers are in the business of avoiding future costs, while accountants are interested in saving money they are spending today (how many people they can do without, fewer pencils they have to buy, etc.).

The following story is true. It represents a simple, but poignant example of the hidden costs of not doing Systems Engineering. This story also points out the fallacy of the short term thinking "who pays for all of this up front Systems Engineering", versus viewing Systems Engineering as an investment in requirements understanding that leads to cost savings on the back end of the project in fewer iterations, shorter schedules, and more satisfied customers.

What's with this humidifier...

Electrostatic plotters are used extensively in many companies, their high speed, high quality output is used for plotting drawings, circuit boards, and schedules. The electrostatic drawing process (magnetically charging a point on paper) requires specialized environmental conditions including controlled temperature and humidity levels. The temperature/humidity conditions of a computer room are ideal and many times these work horse plotters are collocated with the computers used in creating the drawings.

The tale begins...

During the expansion days of the new site, computer room space was at a premium with no room for computer peripherals. To make room for additional computers, the heavily used electrostatic plotters would be moved out of the computer room to a centrally located area where everyone could have easy access to their drawings. Facilities created a small room where the plotters could be situated. The requirement that the room be maintained at 50% humidity level required a humidifier be placed in the room (due to the dry weather and dehumidifying furnaces). Commercial grade humidifiers which could
handle the load were expensive (~$10,000), would require specialized plumbing, conditioned water, and additional air conditioning capacity. Since facilities had not budgeted engineering time or forecasted capital dollars for the purchase and installation of such a unit, they opted to buy a household humidifier from Sears ($60). They rolled it in, plugged it in, and turned over the owners manual.

Within the first few days, it was discovered that the single humidifier could not maintain the required humidity level--so a second Sears humidifier ($60) was purchased and plugged in. Each humidifier evaporated about 10 gallons of water per day. Two 5 gallon buckets were acquired and each morning two trips to the nearest custodial closet (the buckets would not fit under a bathroom sink) were made to fill the humidifiers. Since no one wanted to do the daily task of filling the humidifiers, the low man on the totem pole was relegated to the menial task of hauling water. After several complaints about snide comments made during the filling task to the drafting manager, the task was added to the morning duty roster of the non-exempt drafting folks with the job rotated on a daily basis. Policies were worked out for exemption to the job of filling the humidifiers during vacation (trade with someone), disabilities (a doctor's note), or gender (bonafide weight lifting restrictions).

Of course, not all water haulers were careful during their trips, and water was inevitably spilled along the way. Several slips and falls were accounted for and written up with "water on the hallway floor" as the culprit.

It wasn't too long before someone threw out their back hauling the heavy water containers, resulting in an expensive workman's compensation claim.

If that wasn't enough, it showed up on the yearly attitude survey and a number of lengthy meetings were called to figure out why job satisfaction in the Drafting Dept. had taken such a sharp fall.

That's when a Quality Improvement Team got involved (with a former plumber on the team) and suggested running a water line to the humidifiers with a tap and hose used to fill the humidifiers. After some brainstorming, they took it a step further and recommended hooking up the humidifiers with a float valve (about $10 worth of parts) so the humidifiers could fill themselves. They won Quality Improvement Idea of the month and lunch on the company.

The idea in the form of a "back of napkin" drawing was turned over to the building maintenance department, who began engineering the job. They decided that since float valves can fail (stay open), they needed a double redundant, fail safe system consisting of dual, electric servo valves, electric-eye sensors, with redundant float-valve cut-off switches. The system was installed over a weekend (on double overtime) so the humidifier would not be offline during production ($7,800 engineering and material bill).

Figure 1: Original "back of napkin" drawing of water hookup for humidifier--what the customer wanted.
The first flood/failure of the double-redundant electric-eye, automatic humidifier refill system happened over a weekend. We were greeted by an inch of water over several thousand square feet. Maintenance quickly resolved the situation (copper sliver stuck in a valve), got the water turned off, blew out the pipes, got the water cleaned up, and rented special high speed drying equipment. The Drywall was damaged and needed to be replaced along with the carpet (which had grown mildew).

The second flood happened as a result of a power failure, which enabled a miswired servo valve to open when no power was present. Luckily, the power outage was only several hours and during regular business hours.

Since these household humidifiers were not built to run 24 hours-a-day as the "tandem" was doing, the plastic parts began to wear out. Since these humidifiers were on the critical path (the humidity was required to plot the drawings that were on the critical path of the critical projects), maintenance was called in to fix the problem. Since no parts were in stock at the local Sears, a custom built part was machined in the model shop. These humidifiers needed to be put under a maintenance agreement. Sears was contacted about an < 4 hour response service agreement on the household humidifiers--which Sears did not offer (who would want to have an expensive service agreement on a $60 household humidifier?). A preventative maintenance schedule was put in place. Spare parts were ordered, part numbers were assigned, and incoming inspection drawings and procedures were implemented. Another Quality Improvement Team undertook a pareto analysis to identify which parts failed the most and were therefore most critical to keep in stock. They also won Quality Improvement Idea of the Month for eliminating ~20 parts from stock that were at the six sigma failure level (at an estimated $2,000 savings/part).
Things start growing...

There began to be a rash of respiratory problems and other illnesses in the area. An expensive "sick building" study was ordered to see if any environmental conditions in the area could contribute to the noticeable increase in sick days being reported (and showing up in the overhead accounts). The audit pointed out that the humidifiers could be the source of the problem. Cultures were taken and identified as being a major contributing factor. Since the humidifier automatic double-redundant filling system had not been designed for quick disconnect as originally intended (i.e. by unscrewing a hose connection, instead it required an electrician and a plumber several hours work to unhook each humidifier), a chemical approach was used. Chlorine bleach was added to the humidifiers on a regular basis and included in the weekly job roster. Since chlorine is considered a hazardous chemical, a new hazardous chemical vault was required to store the chlorine bleach. Special classes on the handling of hazardous chemicals were taught to all personnel in the area and the site HAZCOM documentation and chemical warning signs were updated to reflect the new chemical in use on the site. Additional procedures were put in place for the disposal of hazardous empty bleach containers.

The dosing of the humidifiers with bleach was not an exact science. Spills occurred and clothes were ruined (and purchased by the company), which in turn caused lab coats and safety glasses to be put on before adding the chlorine (the brown carpet also had its share of white spots). Eventually, someone overdosed the humidifiers and the fumes became overwhelming in parts of the building. A hazardous chemical emergency was called and part of the building evacuated and the city hazardous chemical emergency unit called in to investigate.

No more chemicals...

Since chlorine was no longer allowed, maintenance began charging $300/month to have facilities engineers disconnect the humidifiers, have them cleaned, and reconnected (overtime/off-shift of course).

When the site shutdown was announced, it was rumored that the facility was closed because the site was just not productive enough, not making enough money, and the worker's poor attitude--but we all knew it was the humidifiers.

Conclusion

The point here is not to poke fun of building maintenance, company bureaucracy, use of electrostatic plotters, or anything else, but rather point out all of the downstream affects and costs of the short term thinking in cost savings/ROI. Looking at just the expensive up front investment in a industrial grade humidifier system in and of itself was a valid decision, but not when taking into account all the foreseeable downstream ramifications/costs. Systems Engineering is in the business optimizing the whole system, cost, reliability, environmental, ergonomics, maintainability, and all the other myriad items that impact on the problem to come up with an overall optimum solution (or even eliminating the need for electrostatic plotted drawings by electronic drawing delivery to begin with).

Because we could not afford to spend the time and money up front to Systems Engineer a valid approach to begin with, we made an initial decision not to invest in a needed solution that in the long run would have avoided the additional 10-50 X the costs in "get by" bandage solutions, slipped program schedules, and unknown amounts in lost productivity--all of which is real money.

Postscript

As a fitting final tribute to the humidifiers at site closure, we took the humidifiers up on the roof of the office building and threw them off.

AUTHORS' BIOGRAPHY

Mark E. Sampson works in marketing at TD Technologies' SLATE Division in Dallas, Texas. He is a graduate of Brigham Young University (BSCE) and University of Southern California (MS-Systems Analysis/Management) and has over 14 years experience in applying automation tools to various engineering disciplines, including Systems Engineering. Part of his job includes justifying the investment in Systems Engineering tools to managers and accountants; this allegory is a result of his search for simple, clear reasoning for investing in Systems Engineering that vice-presidents and accountants can understand.